

**F I N A L**

**REPORT OF FINDINGS, YEAR 1 (1995),  
DESERT TORTOISE MONITORING SURVEYS  
ALONG THE SOUTHERN BOUNDARY OF  
THE NATIONAL TRAINING CENTER  
FORT IRWIN,  
SAN BERNARDINO COUNTY, CALIFORNIA**

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**Chambers Group, Inc.**

## F I N A L

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## **SECTION 1 - INTRODUCTION**

### **1.1 PURPOSE OF STUDY**

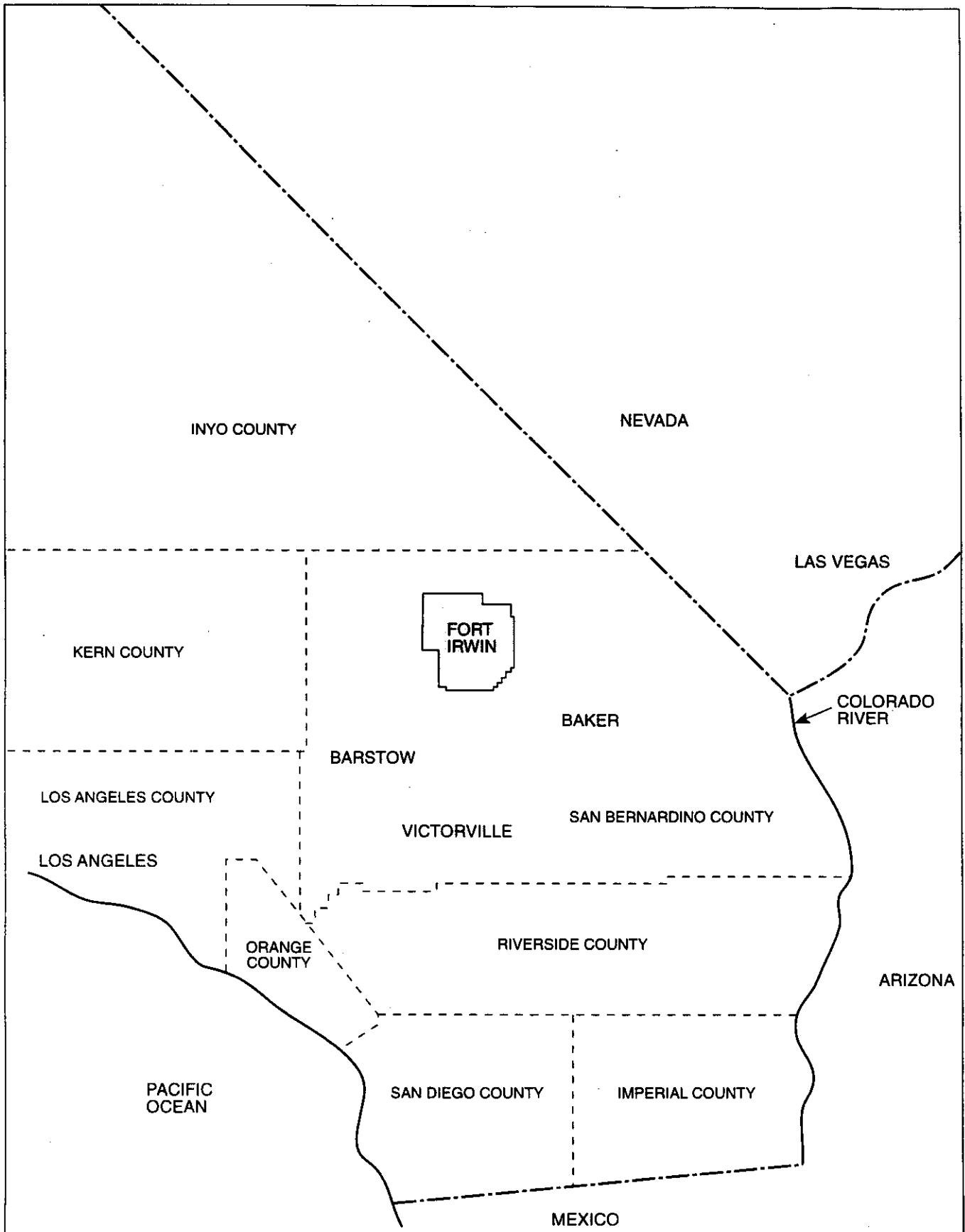
As part of the effort by the U.S. Army at Fort Irwin and the U.S. Army Corps of Engineers (Corps) to monitor desert tortoise (*Gopherus agassizii*) populations along the existing southern border of the National Training Center (NTC), Chambers Group, Inc. (Chambers Group), was retained to conduct a monitoring census of current tortoise populations within this region. The principal goal of the study was to obtain a set of mark-recapture data for desert tortoises within the area, which will be used as part of a long-term study of desert tortoise populations along the southern boundary of Fort Irwin. Fort Irwin is required to monitor desert tortoise populations as part of the terms and conditions set forth by a 1995 Biological Opinion from the U.S. Fish and Wildlife Service (USFWS 1995). The data gathered from this study will be used to estimate the baseline (current) desert tortoise population; future population estimates of the desert tortoises in this area will be compared to the baseline estimate to identify any population trends.

In accordance with the USFWS 1991 Biological Opinion for the current mission at the NTC at Fort Irwin, a large portion of land has been protected along the southern boundary of Fort Irwin to contribute to the long-term conservation of the desert tortoises. The area established for the desert tortoises is found along the southern border of the NTC, from the Universal Transverse Mercator 3890000 north line (90 UTM grid line) south to the southern boundary of Fort Irwin. A more recent Biological Opinion by the USFWS (1995) has determined that the desert tortoise population in the southern part of the NTC will need to be monitored to determine population trends and assess the effect (if any) of the current training mission on desert tortoises south of the 90 UTM grid line.

This report presents results of the initial monitoring study conducted in the spring of 1995. The size of the desert tortoise population estimated during this initial monitoring study will be used to compare estimated population sizes in future yearly monitoring studies. Continued monitoring of desert tortoise populations on Fort Irwin is needed to provide important insight into the long- and short-term management of the desert tortoises relative to NTC operations. Additionally, the study will provide a comprehensive, long-term environmental database of the region in the context of desert tortoise biology.

### **1.2 FORT IRWIN AND THE NATIONAL TRAINING CENTER**

The NTC at Fort Irwin is currently the fifth largest military ground training facility in the nation, occupying 1,004 square miles (approximately 642,820 acres) in the western Mojave Desert of California. It is located between Las Vegas, Nevada, and Los Angeles, California, and is approximately 50 kilometers (30 miles) northeast of the City of Barstow in San Bernardino County, California (Figure 1-1). Geographically, the NTC is bordered by the Alvord Mountains on the south, Owlshead Mountains on the north, the Lane Mountains and Eagle Crags on the west, and the Soda and Avawatz Mountains on the east.



Not to Scale

**REGIONAL MAP:**  
**NATIONAL TRAINING CENTER AT FORT IRWIN**  
Figure 1-1

### **1.3 STUDY AREA**

For the 1991 USFWS Biological Opinion, the 90 UTM grid line was established as an off-limits area for training vehicles within Fort Irwin. The area within the NTC below the 90 UTM grid line was designated as protected desert tortoise habitat, and military vehicular traffic is still prohibited. Barbed wire fencing has been installed along the 90 UTM grid line to prevent military vehicles from entering the desert tortoise habitat. This physical barrier has prevented the area from being used for training purposes. The Mannix Trail is a military convoy route that runs north and south through the protected area. It is also fenced on each side from the southern border up to the 90 UTM grid line to prohibit military traffic from driving through the area. The protective fencing is intended to prohibit vehicular traffic only; it is not designed to inhibit wildlife movement.

Eight desert tortoise monitoring study plots (Figure 1-2) were identified along the southern boundary of the NTC, south of the 90 UTM grid line. Four study plots are located on Fort Irwin, and the other four are located south of the boundary of Fort Irwin on land managed by the U.S. Department of Interior, Bureau of Land Management (BLM). It should be noted that there is no AL-5 labeled. This randomly generated study plot was located in the Alvord Mountains, and no surveys were conducted on this plot. The study plots were chosen in areas where desert tortoises had been previously observed (Krzysik 1991; Chambers 1994). The vegetation community within the study area (and over most of Fort Irwin) is creosote bush scrub, with the exception of a small amount of alkali sink vegetation in the vicinity of Coyote Lake and an isolated stand of Joshua trees on the upper slopes of the Alvord Mountains. The dominant physiographic features of the study area include the moderate to steep slopes of the Alvord Mountains, washcut bajadas along the foothills north and south of the Alvords, low hills to the west and east, and many areas of gently sloping plains. Elevation in the study area ranges from 730 to 915 meters (m) (2,400 to 3,000 feet). Much of the Alvord Mountains lie south of the 90 UTM grid line and have not recently been used for training purposes.

### **1.4 THE DESERT TORTOISE**

The desert tortoise is a large herbivorous reptile inhabiting the deserts of southwest United States. It is a long-lived species, reaching sexual maturity between 12 and 20 years. Desert tortoises can be divided into two distinct races based on morphological and genetic characteristics. These races are described as the Mojave race, which is associated with the Mojave Desert in California, Nevada, and Utah, as well as a portion of Arizona; and the Sonoran race, associated with the Sonoran Desert in Arizona. This study addresses the eastern extreme of what can be considered the western population of the species, which occurs between the San Bernardino Mountains and the general vicinity of Baker, San Bernardino County, California.

The desert tortoise is a spring-active species and demonstrates a somewhat more limited activity pattern throughout the summer and into the fall. It possesses a fairly large home range (in excess of 20 to 50 acres) that is locally defended from other desert tortoises. Tortoises construct burrows with a single opening that they enter at night and during high midday temperatures. They are herbivorous, but not dietary specialists, feeding on a variety of herbaceous plants and

# Study Area

## SOUTHERN BOUNDARY AND STUDY PLOT LOCATIONS

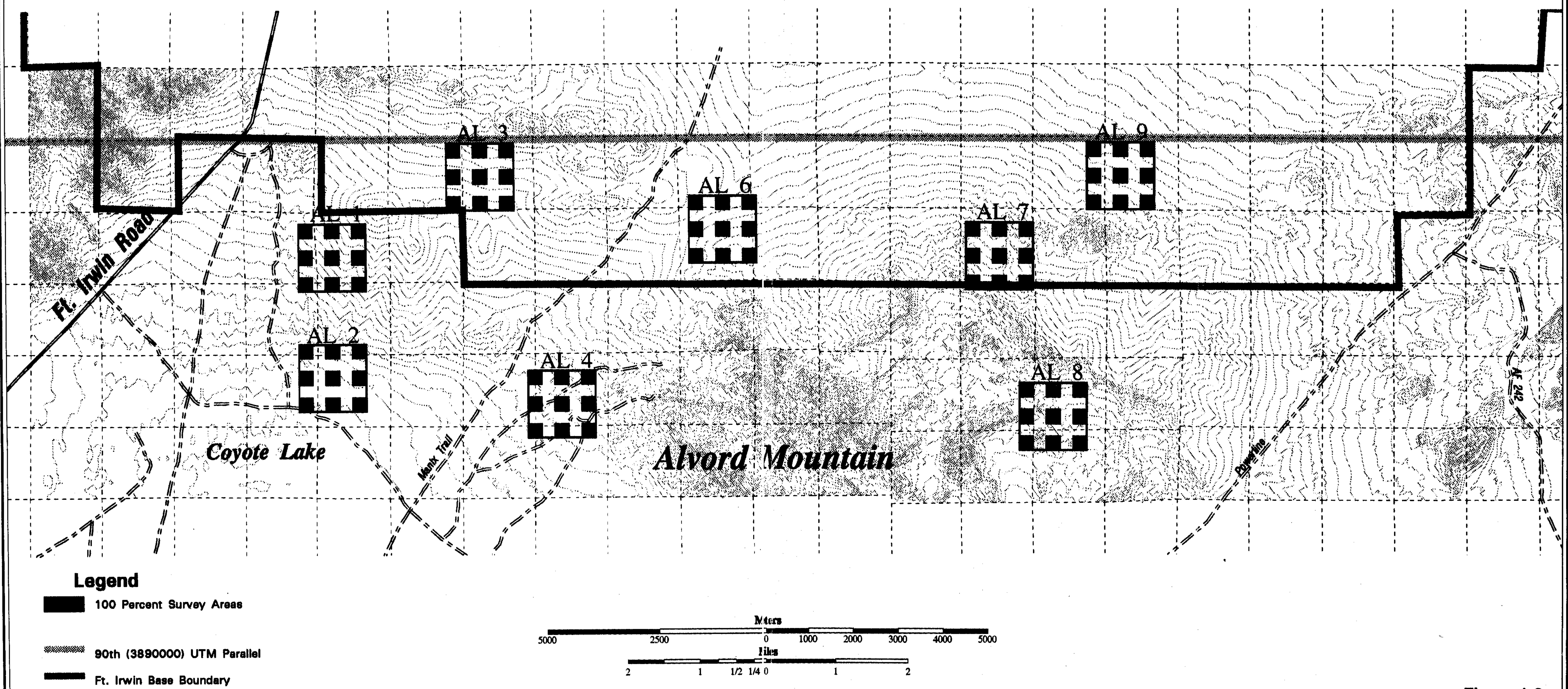


Figure 1-2



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grasses. The species is fully adapted to dry desert life but will drink from seasonal pools, if available.

The desert tortoise was formally listed by the USFWS as Threatened in 1990, in accordance with the Endangered Species Act of 1976, as amended. Prior to its listing by the USFWS, the species was listed as State Threatened in 1989 by the California Department of Fish and Game (CDFG). As part of an effort to stop the decline of the desert tortoises, and to plan for the recovery of this species, portions of California were designated as critical habitat for the survival of the desert tortoises by the USFWS (1994). Critical habitat encompasses portions of the Mojave and Colorado deserts that contain the primary constituent elements and focuses on areas that are essential to the species' recovery.

To coordinate efforts for recovery of the desert tortoises, the Desert Tortoise Recovery Plan was implemented to contribute to the overall conservation of the species (USFWS 1994). The Plan divides the range of the desert tortoises into six distinct population segments or recovery units. One such unit, the Western Mojave Recovery Unit, consists of approximately 4,753,000 acres, located entirely in California. Forty-five USGS quadrangle sections along the southern boundary of Fort Irwin are located in the Superior-Cronese critical habitat unit (CHU), one of four CHUs designated in the Western Mojave Recovery Unit.

The NTC is taking these steps to comply not only with the USFWS Biological Opinion, but also to contribute to the conservation, management, and recovery of the desert tortoises. Continued desert tortoise monitoring and management programs within the NTC will benefit the overall success of the species in this region of the Mojave Desert.

## **SECTION 2 - MATERIALS AND METHODS**

### **2.1 PLACEMENT OF STUDY PLOTS**

As part of a separate study for the NTC regarding desert tortoise habitat modeling, study plots were placed randomly within different general landforms (such as basalt, granitic alluvium, and so forth; S. Ahman, personal communication). The eight study plots were randomly selected in proportion to the total acreage of landforms found in the study area. Locations of the study plots are presented in Figure 1-2. Each study plot was placed in areas where desert tortoises are expected to occur, based on extensive surveys of the entire southern boundary region in 1992 and 1993 (Chambers 1994).

### **2.2 STUDY PLOT SIZE AND CONFIGURATION**

For the current study, surveys were conducted on eight study plots, 1,500 x 1,500 m, or 2.25 sq. km (4,922 x 4,922 ft, 0.87 sq. mi) in size. Each study plot was divided into a checkerboard pattern of twenty-five 300 x 300 m (0.09 sq. km) quadrats. Within each study plot, nine sample quadrats were chosen for 100-percent coverage surveys. The sample quadrats were evenly spaced throughout the study plot, so that no two sample quadrats shared a common border (Figure 2-1). The area surveyed in the nine sample quadrats represented 36 percent, or 0.81 sq. km (0.31 sq. mi) of the total area of each study plot. This area approaches the size of the typical 1 x 1 km (1 km sq.) BLM study plot.

### **2.3 SURVEY PROTOCOL**

Surveys were conducted by two teams of five surveyors. Each team consisted of at least two desert tortoise biologists with over 60 field days (500 hours) of experience in handling desert tortoises and identifying tortoise sign (including live tortoises, shells, bones, scat, burrows, tracks, eggshell fragments, and so forth). Other team members had varied desert tortoise experience but were trained in the field prior to the current study.

Surveyors walked a series of parallel belt transects approximately 15 m (45 feet) wide, walking 15 m apart for a 100-percent sweep of each quadrat. Four sweeps of parallel belt transects were needed to completely cover each quadrat with five surveyors. Transects began at one corner of a quadrat, with surveyors walking belt transects along a cardinal compass heading (north to south, south to north, or east to west, west to east) to minimize double coverage of an area. The initial heading in which belt transects were walked was alternated for each survey to minimize bias caused by extraneous factors such as the position of the sun and its effect on shading, and vegetative overgrowth that might obstruct the view of surveyors walking one direction while having no effect on a surveyor walking in the opposite direction.

# Study Plots

## STUDY PLOT AND QUADRAT CONFIGURATION

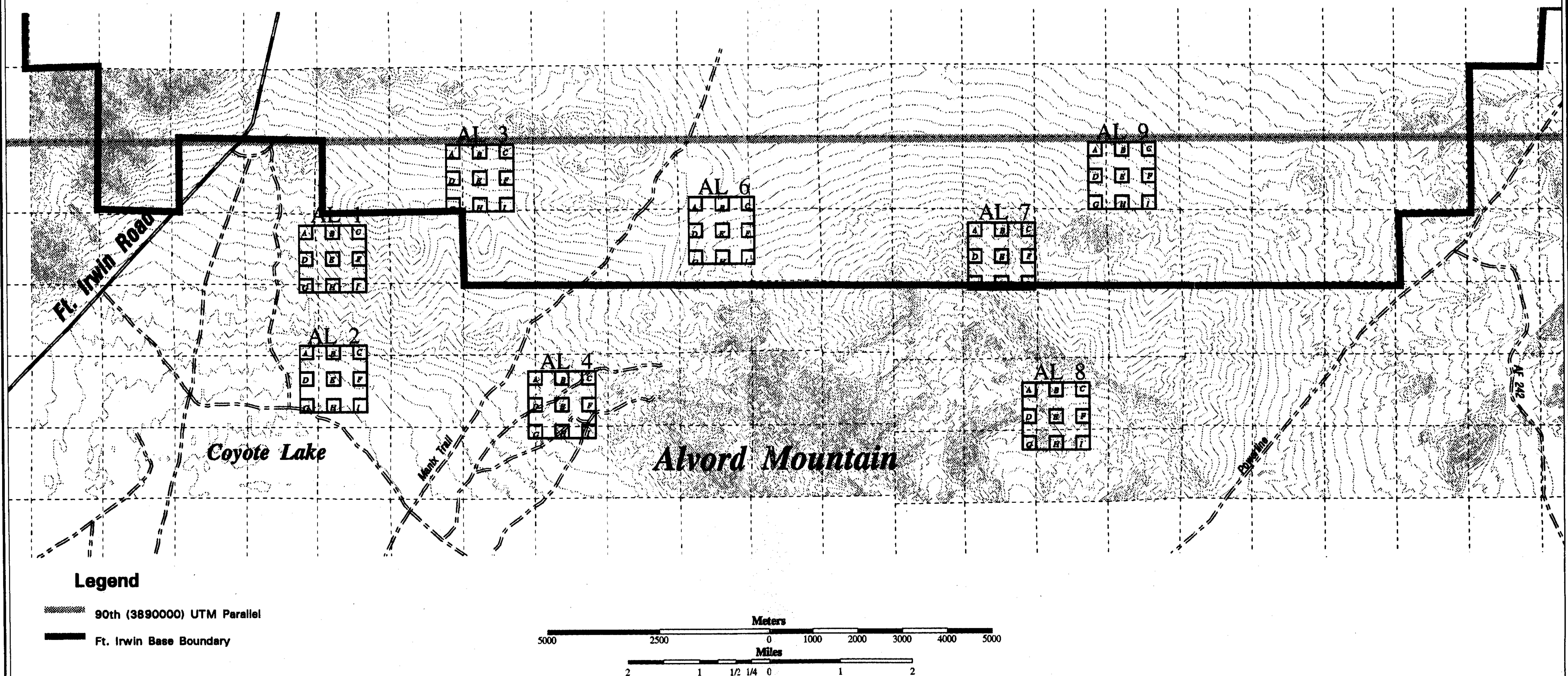


Figure 2-1

The order and pattern in which the quadrats on a study plot were surveyed varied from visit to visit. One of four pre-chosen patterns was followed so that the quadrats were surveyed at different times of the day. Survey plot patterns, as well as the configuration and labeling of quadrats within each study plot, can be found in Appendix A. Also, the first and last quadrat to be surveyed per visit were situated in each pattern so that the surveyors would end the survey fairly close to their starting point. This was done to minimize the distance needed to return to the starting point (and the field vehicle) at the end of the survey day.

Of the nine quadrats within a study plot, eight could be surveyed over the course of 1 day, or per visit. Each study plot was surveyed a minimum of three times. Those with no live tortoises and little sign by the third visit were not surveyed again for the year. Study plots with numerous tortoise captures were surveyed up to six times, depending on time, weather, and tortoise activity constraints.

Each quadrat (and study plot) was oriented to true north and south to facilitate transect navigation through the study plot. Quadrats were permanently marked with metal poles (approximately 2.5 m [8.2 ft] in height) at each corner point. Mylar strips and fluorescent surveyor flagging were placed at the top of each post for better viewing at a distance.

The spring desert tortoise monitoring surveys were conducted from April 11 to May 5, 1995, with additional visits on June 10, 11, 17, and 18, 1995. Surveys in each quadrat were conducted at different times of the day, when environmental conditions were most favorable for desert tortoise activity. Surveys were discontinued or not initiated if conditions became unfavorable, such as during heavy rain, high winds that impaired surveying ability, or extremely high or low temperatures.

Surveys were conducted to mark and recapture as many live desert tortoises as possible during the survey period. All tortoise burrows were checked during each survey (and rechecked in subsequent surveys), and non-tortoise burrows that had potential to house tortoises were also checked. Data were collected for all individual tortoises encountered (live tortoises above ground and in burrows). For initial captures, the time, date, identification number, Global Positioning System (GPS) location, maximum carapace length (MCL), width, sex, health and condition of the animal, shell wear and condition, burrow information (if applicable), and any additional notes were recorded on standardized data sheets (see Appendix B). Trimble GPS units were employed to record location data (within 5 m [16.4 ft]) for all encounters. As an alternative to notching the tortoise carapace, live tortoises were permanently marked by using passive integrative transponder (PIT) tags adhered to the caudal end of the carapace with a nontoxic adhesive for long-term identification. A unique number for each tortoise was written on the carapace (above the PIT tag) using a waterproof marker covered with clear, nontoxic nail polish. The written number was a temporary identification for use during the 1995 season. Tortoises were handled using protocol described in the "Guidelines for Handling Desert Tortoises During Construction Projects," compiled by the Desert Tortoise Council (1994) to minimize transmission of any potentially harmful disease. Desert tortoise biologists on each team possessed the necessary USFWS permits to handle and tag tortoises (USFWS Permit No. SCHNABEL-AGENT).

Other incidental data collected during surveys include recent desert tortoise sign such as carcasses, burrows, and scat. All sign encountered was recorded on standardized data sheets, and all sign observed was marked (carcasses with surveyor's tape, scat and burrows with a marking on the ground next to the sign) so that they would not be counted on subsequent visits. Sign data were collected to determine relative use of an area by tortoises.

## 2.4 DESERT TORTOISE DENSITY ESTIMATES

A population estimate for each desert tortoise study plot was calculated using the Schnabel mark-recapture method. The Schnabel method is a standard method for mark-recapture estimates of population size. It is applied when the population can be assumed to be closed (i.e., if birth, death, immigration, and emigration are negligible), and there are multiple trapping sessions in which each "new" animal captured is marked and returned to the area (Seber 1982). Because the survey window had a short duration and surveys were conducted prior to the year's first hatchlings, it is reasonable to assume that death rates are negligible, and that no births occurred during the survey period. Immigration and emigration are assumed to be negligible because of the limited survey period and the greater area covered by the nine evenly spaced quadrats.

## **SECTION 3 - RESULTS<sup>1</sup>**

### **3.1 ENVIRONMENTAL CONDITIONS**

Weather conditions were representative of the Mojave Desert climate during the spring surveys. Cloud cover was highly variable, ranging from 0 to 100-percent coverage. Wind speeds for most survey days were generally calm (none) to light, with several days of winds ranging from moderate to heavy. Soil temperatures (taken during tortoise processing) ranged from a low of 13°C to a high of 52°C, and were usually coolest in the morning and highest by mid- to late-afternoon, reflecting ambient temperatures. Three surveys were postponed because of heavy winds and/or cool temperatures. Only one survey day was postponed due to rain and thunderstorm conditions.

### **3.2 RESULTS OF 1995 SPRING SURVEYS**

A total of 144 live desert tortoises were encountered (including marks and recaptures) and recorded during the study (two anecdotal sightings of male desert tortoises were made off the study area and were not included in the analysis; they were, however, marked and processed). Of the 144 tortoise encounters, 111 were processed and tagged as initial captures, 25 were recaptures, and 8 could not be identified as an initial capture or recapture because they were too deep inside burrows to be extricated for processing (Table 3-1).

Subadult and adult tortoises (>180mm MCL) were sexed when possible. Tortoises less than or equal to 180mm MCL are considered to be immature or juvenile animals and too small/young to positively identify the sex using external morphology. Adults and subadults accounted for 98 of the 111 marked individuals; the other 13 were immature/juveniles. The overall ratio of adult/subadult to immature/juvenile is 7.5:1 for the entire study area. Histograms showing the frequency of individuals within discrete size classes (Turner and Berry, 1984) for all study plots is shown in Figure 3-1.

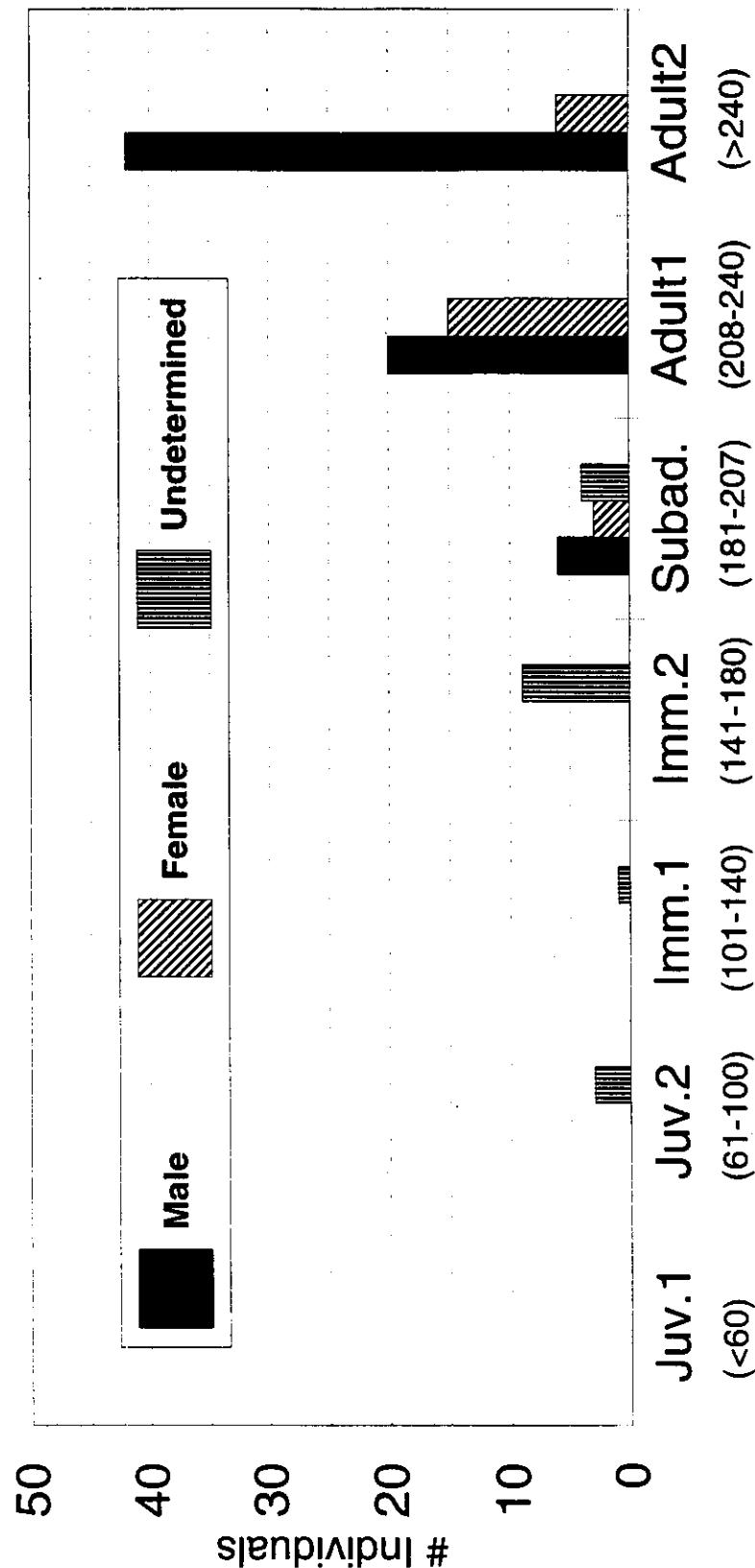
Of the initially captured adult/subadult desert tortoises, 67 were males, 25 were females, and six tortoises were of sufficient subadult size, but sex could not be determined by simple field methods. Eight additional adult tortoises were not sexed because they were too deep in burrows to be extricated for processing. The overall ratio of adult males to adult females for the eight study plots was 2.7:1. A total of 13 juvenile/immature tortoises were observed on all study plots during the study. Table 3-1 lists the demographic information totals for the entire study, as well as information for each study plot (discussed below).

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<sup>1</sup>Throughout the following section, "tortoise encounters" refers to all desert tortoise sightings, including initial captures and recaptures.

| Study Plots:                      | # Males   | # Females | Male to Female ratio | over 180mm (sex undet.) | 180mm or less | unidentified /deep in burrow | Total observed | Total recaptures |
|-----------------------------------|-----------|-----------|----------------------|-------------------------|---------------|------------------------------|----------------|------------------|
| AL1                               | 19        | 8         | 2.4:1                | 3                       | 2             | 2                            | 34             | 5                |
| AL2                               | 9         | 4         | 2.3:1                | 0                       | 4             | 1                            | 18             | 6                |
| AL3                               | 13        | 6         | 2.2:1                | 1                       | 1             | 4                            | 25             | 7                |
| AL4                               | 0         | 0         | 0                    | 0                       | 0             | 0                            | 0              | 0                |
| AL6                               | 7         | 3         | 2.3:1                | 1                       | 1             | 0                            | 12             | 3                |
| AL7                               | 9         | 1         | 9.0:1                | 1                       | 4             | 0                            | 15             | 2                |
| AL8                               | 7         | 1         | 7.0:1                | 0                       | 0             | 0                            | 8              | 2                |
| AL9                               | 3         | 2         | 1.5:1                | 0                       | 1             | 1                            | 7              | 0                |
| <b>Total of all observations:</b> | <b>67</b> | <b>25</b> | <b>2.7:1</b>         | <b>6</b>                | <b>13</b>     | <b>8</b>                     | <b>119</b>     | <b>25</b>        |

DEMOGRAPHIC INFORMATION FOR DESERT TORTOISE  
OBSERVED ON THE FORT IRWIN STUDY PLOTS, SPRING 1995.  
Table 3-1



\*Juv. = Juvenile, Imm. = Immature, Subad. = Subadult, MCL = maximum carapace length

\*Four tortoises did not have sufficient data to determine sex and/or MCL

TORTOISE SIZE CLASS  
FREQUENCIES, SPRING 1995.  
Figure 3-1

Data collected during the study were used to determine size-weight relationships and sexual dimorphism. Male desert tortoises captured during the study were on average larger than the captured females, in both weight and MCL (Table 3-2). The mean average weight (rounded to the nearest gram) for males and females was 3,151 grams (g) and 2,392 g, respectively. The mean average MCL was also larger in males than in females, measuring 248 mm and 228 mm, respectively. Males ranged more widely in size, with weights from 1,100 to 5,000 g and MCL from 184 to 290 mm. The variation in size for the females ranged from 1,450 to 3,200 g in weight and 196 to 252 mm in MCL.

The relationship between desert tortoise weight and shell size between sexes was analyzed. Four different shell size measurements were used: MCL, carapace width, carapace area (calculated as the area of the ellipse having MCL as major axis and carapace width as minor axis), and the ratio of MCL to carapace width. Table 3-2 shows descriptive statistics by sex for those variables and for tortoise weight. Carapace area performed best as a predictor of tortoise weight and was used to develop regressions between sexes. Summaries of regressions of weight on carapace area, done separately for the two sexes, and a plot of the regression results are shown in Appendix C. There does not appear to be any appreciable difference between males and females in the relationship between carapace area and body weight.

### 3.3 STUDY PLOT RESULTS

Locations of all desert tortoise encounters during the study, including recaptures and tortoises seen deep inside burrows, are shown on Figure 3-2. The number of tortoise encounters throughout the study area ranged from no tortoise encounters on plot AL-4 to 39 encounters on plot AL-1.

Plot AL-1 had the highest number of adult desert tortoises (27), with AL-3 (19) and AL-2 (13) having the second and third highest number of adult tortoises, respectively. AL-6 and AL-7 each had 10 adult tortoises, AL-8 had 8 adults, and 5 adult tortoises were observed on AL-9 (see Table 3-1). No desert tortoises were observed on plot AL-4.

Male-to-female sex ratios varied for each study plot (see Table 3-1). The highest male-to-female ratios occurred on the eastern study plots. Nine males were observed to every one female observed on plot AL-7 (a 9.0:1 male to female [m/f] ratio), and plot AL-8 had a 7.0:1 m/f ratio. Plots AL-1, AL-2, AL-3 and AL-6 all had similar m/f ratios, ranging from 2.2:1 (AL-3) to 2.4:1 (AL-1). These study plots also had the highest number of tortoise encounters per plot. Plot AL-9 had a 1.5:1 male/female ratio.

The plots with the highest number of observed immatures and juveniles were plots AL-7 and AL-2, both with four (Table 3-1). Two immature/juvenile tortoises were observed on plot AL-1, and one immature/juvenile tortoise was observed on plots AL-9, AL-6, and AL-3.

The number of recaptured desert tortoises for each study plot was relatively low. Plots AL-3, AL-2, and AL-1 had the most recaptured tortoises with 7, 6, and 5, respectively. There were 3 recaptured tortoises on plot AL-6, 2 recaptures on AL-7 and AL-8, and no recaptures occurred on plot AL-9. Table 3-1 shows the number of tortoises marked and recaptured for each plot.

**FEMALES (n=24)**

|                                   | <b>Weight</b> | <b>MCL</b> | <b>Width</b> | <b>Area</b> | <b>(MCL/Width)</b> |
|-----------------------------------|---------------|------------|--------------|-------------|--------------------|
| <b>Minimum</b>                    | 1450          | 196        | 152          | 23860.40    | 1.202              |
| <b>Maximum</b>                    | 3200          | 252        | 193          | 37604.864   | 1.399              |
| <b>Mean</b>                       | 2391.667      | 228.402    | 176.292      | 31696.150   | 1.295              |
| <b>Standard Deviation</b>         | 468.732       | 15.247     | 12.189       | 4097.161    | 0.047              |
| <b>Standard Error of the Mean</b> | 95.68         | 3.112      | 2.49         | 836.330     | 0.010              |
| <b>Coefficient of Variation</b>   | 0.196         | 0.067      | 0.069        | 0.129       | 0.036              |
| <b>Median</b>                     | 2475          | 229.5      | 179          | 31777.21    | 1.296              |

**MALES (n=66)**

|                                   | <b>Weight</b> | <b>MCL</b> | <b>Width</b> | <b>Area</b> | <b>(MCL/Width)</b> |
|-----------------------------------|---------------|------------|--------------|-------------|--------------------|
| <b>Minimum</b>                    | 1100          | 184        | 135          | 19509.29    | 1.128              |
| <b>Maximum</b>                    | 5000          | 290        | 235          | 53524.885   | 1.363              |
| <b>Mean</b>                       | 3151.364      | 247.803    | 198.348      | 39030.778   | 1.253              |
| <b>Standard Deviation</b>         | 918.887       | 25.598     | 23.194       | 8061.781    | 0.053              |
| <b>Standard Error of the Mean</b> | 113.107       | 3.151      | 2.855        | 992.337     | 0.007              |
| <b>Coefficient of Variation</b>   | 0.292         | 0.103      | 0.117        | 0.207       | 0.043              |
| <b>Median</b>                     | 3125          | 250        | 203          | 39739.576   | 1.25               |

**DESCRIPTIVE STATISTICS, BY SEX, FOR THE VARIABLES  
USED IN THE ANALYSIS OF SIZE-WEIGHT RELATIONSHIPS.**

Table 3-2

# Tortoise Locations

## LOCATIONS OF TORTOISES ENCOUNTERED DURING 1995 SURVEYS

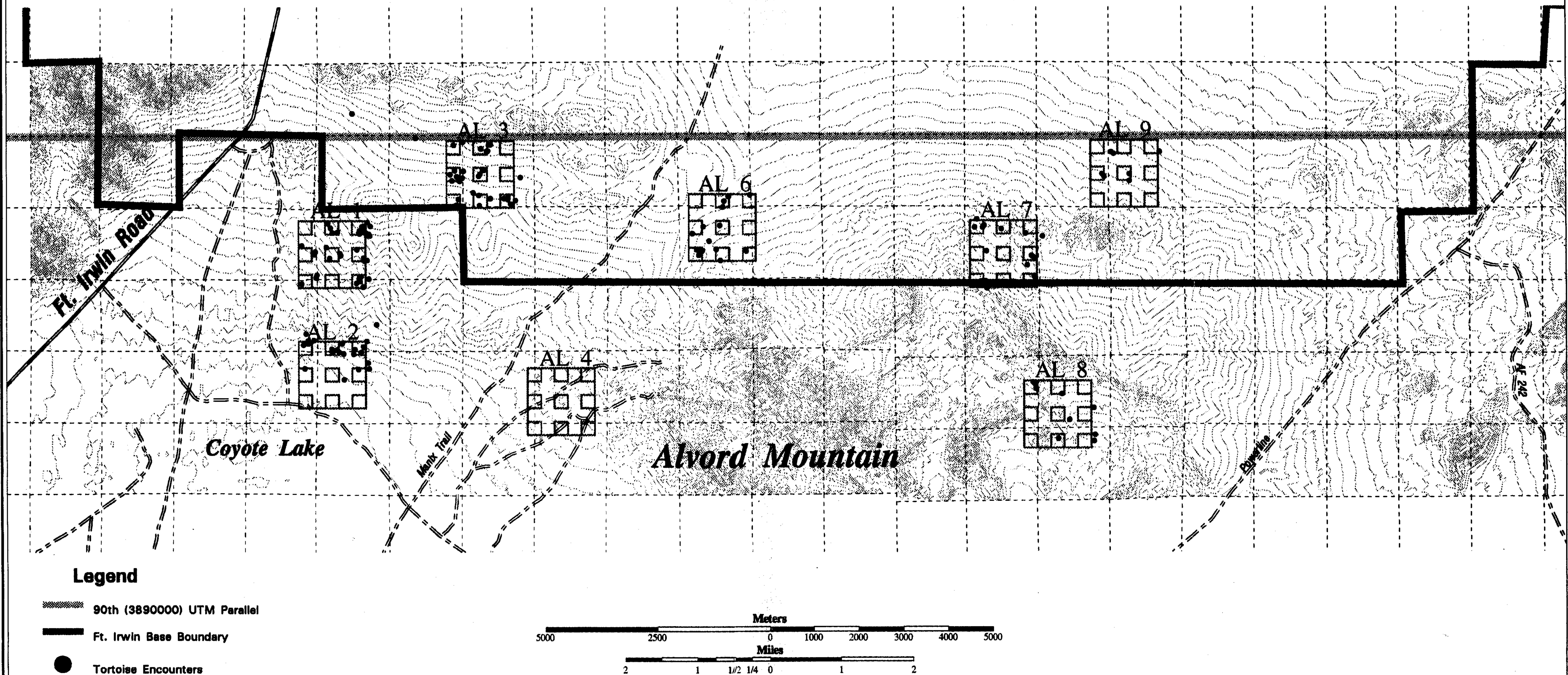


Figure 3-2

In addition to the total number of tortoise encounters per study plot, tortoise encounter (capture) success was calculated for each plot. The average number of tortoise encounters per survey team per visit is illustrated in Table 3-3. This table shows tortoise capture success by study plot, the total number of visits to each plot, and the number of tortoises encountered per survey team.

An average of 3.9 tortoises were encountered per survey for the entire study (a combined total of 37 visits were conducted for all plots). Tortoise encounters per visit followed a similar pattern as the total number encountered per plot. Plot AL-1 had the highest tortoises capture success (7.8 tortoises per visit). Plot AL-2 had the second highest capture success rate with 6.0 tortoises observed per visit, and AL-3 had the third highest capture success (5.3 tortoises encountered per visit). This differs from the totals for overall tortoise encounters, where AL-3 was second highest and AL-2 third.

In addition to live tortoise encounters, recent tortoise sign, such as scat, burrows and carcasses, were also recorded. Table 3-4 shows sign type and frequency encountered at each plot during the survey. Also included in this table is the total sign observed per plot and the average number of tortoises sign observations per visit. It should be noted that typically all new sign is likely to be observed during the first or second visit (100-percent coverage), and new sign observations should drop after the first couple of visits. The only new sign that should be observed during the latter visits is fresh, newly produced scat, freshly dug burrows (likely overnight burrows), or fresh carcasses (no new carcasses from this season were observed; all carcasses were from at least one previous field season). Calculation of the average number of sign per visit is meant to show relative use of a study plot by desert tortoises.

During the 1995 spring survey a total of 614 desert tortoises sign (216 scat, 334 burrows and 64 carcasses) were observed and recorded for the eight study plots. A total of 16.6 sign were observed per visit for the entire study (37 total visits; see Table 3-4). Study plots with the most sign were typically those that also had the most tortoise encounters, and the most tortoise encounters per visit (see Table 3-3). Plots AL-1, AL-3 and AL-2 had the most sign observed per visit, (45.2, 20.3, and 17.8 sign per visit, respectively). In addition, the plots with the least sign observed (AL-4, AL-8, and AL-9) also had the fewest tortoise observations.

### 3.4 DENSITY ESTIMATES FOR EACH STUDY PLOT

Mark-recapture data for the study plots are presented in Appendix C. The Standard Schnabel estimators were used to compute population sizes for each study plot for which recapture data were obtained. The population estimates based on the mark-recapture data are shown in Table 3-5. The low recapture rates are characteristic of some mark-recapture studies of desert tortoises (Freilich, personal communication; Chambers Group 1994).

Desert tortoise density estimates for each study plot were based on the mark-recapture data for the nine quadrats surveyed. For each study plot, the nine quadrats surveyed make up 36 percent of the total study plot area. Plot AL-1 had the highest estimate of tortoise density, with an N value of 98.04 for the nine quadrats (Table 3-5). Plot AL-6 had the second highest estimate with N = 40.38, and plot AL-3 had the third highest with N = 38.72. Plot AL-8 had a tortoise

| Study Plots:                       | # Visits  | # Tortoise Encounters | # Tortoise Encounters/<br>Visit |
|------------------------------------|-----------|-----------------------|---------------------------------|
| AL1                                | 5         | 39                    | 7.8                             |
| AL2                                | 4         | 24                    | 6                               |
| AL3                                | 6         | 32                    | 5.3                             |
| AL4                                | 3         | 0                     | 0                               |
| AL6                                | 4         | 15                    | 3.75                            |
| AL7                                | 5         | 17                    | 3.4                             |
| AL8                                | 5         | 10                    | 2                               |
| AL9                                | 5         | 7                     | 1.4                             |
| <b>Totals for<br/>study plots:</b> | <b>37</b> | <b>144</b>            | <b>3.9</b>                      |

**CAPTURE SUCCESS OF DESERT TORTOISES OBSERVED  
ON THE FORT IRWIN STUDY PLOTS, SPRING 1995.**  
**Table 3-3**

| Study Plots:                   | Total # Visits | # Scat     | # Burrows  | # Carcass | Total # Sign | Sign/Visit  |
|--------------------------------|----------------|------------|------------|-----------|--------------|-------------|
| AL1                            | 5              | 61         | 139        | 26        | 226          | 45.2        |
| AL2                            | 4              | 32         | 31         | 8         | 71           | 17.8        |
| AL3                            | 6              | 30         | 89         | 3         | 122          | 20.3        |
| AL4                            | 3              | 2          | 5          | 2         | 9            | 3.0         |
| AL6                            | 4              | 28         | 19         | 5         | 52           | 13.0        |
| AL7                            | 5              | 38         | 21         | 9         | 68           | 13.6        |
| AL8                            | 5              | 14         | 21         | 5         | 40           | 8.0         |
| AL9                            | 5              | 11         | 9          | 6         | 26           | 5.2         |
| <b>Totals for study plots:</b> | <b>37</b>      | <b>216</b> | <b>334</b> | <b>64</b> | <b>614</b>   | <b>16.6</b> |

DESERT TORTOISE SIGN COUNT INFORMATION  
ON THE FORT IRWIN STUDY PLOTS, SPRING 1995.  
Table 3-4

| Study Plots: | Density Estimates for<br>nine Quadrats<br>(# Tortoises/0.81 sqkm) | Bias         | Variance      | Upper<br>Confidence<br>Limit | Lower<br>Confidence<br>Limit | *Density Estimates<br>(# Tortoises/2.25 sqkm) |
|--------------|---|--------------|---------------|------------------------------|------------------------------|---|
| AL1          | <b>98.04</b>  | <b>12.95</b> | <b>1379</b>   | <b>157.86</b>                | <b>12.3</b>                  | <b>272.33</b>                                 |
| AL2          | <b>28.46</b>  | <b>1.88</b>  | <b>62.65</b>  | <b>42.1</b>                  | <b>11.07</b>                 | <b>79.06</b>                                  |
| AL3          | <b>38.72</b>  | <b>2.47</b>  | <b>114.15</b> | <b>57.2</b>                  | <b>15.31</b>                 | <b>107.56</b>                                 |
| AL6          | <b>40.38</b>  | <b>13.4</b>  | <b>587.67</b> | <b>74.5</b>                  | <b>-20.53</b>                | <b>112.17</b>                                 |
| AL7          | <b>17.15</b>  | <b>1</b>     | <b>20.77</b>  | <b>25.08</b>                 | <b>7.21</b>                  | <b>47.64</b>                                  |
| AL8          | <b>31.35</b>  | <b>21.02</b> | <b>700.13</b> | <b>62.2</b>                  | <b>-41.53</b>                | <b>87.08</b>                                  |

\*Density estimates for the entire study plot were extrapolated from the data from the original nine quadrats surveyed.

density estimate of  $N = 31.35$ , and the density estimate for plot AL-2 was  $N = 28.46$ . Plot AL-7, with an  $N$  value of 17.15, had the lowest tortoise density estimate. No density estimates were calculated for plots AL-4 and AL-9 because there were no recaptures on either plot. Tortoise density estimates for each study plot were extrapolated by dividing the  $N$  value by 36 percent ( $N/0.36$ ). The density estimates for the entire study plots are listed in Table 3-5.

## **SECTION 4 - DISCUSSION**

### **4.1 DETERMINATION OF STUDY PLOT SIZE AND CONFIGURATION**

A problem facing desert tortoise biologists is the difficulty in properly estimating desert tortoise population numbers through mark-recapture methods. This task is difficult because tortoises are mobile and can travel beyond the limits of a study plot over the course of one field season. Tortoises captured once during a survey are often not seen again for the season. This typically results in a low frequency of tortoise recaptures during a study, and recapture numbers are often too low to provide adequate numbers for current mark-recapture equations (Chambers 1994).

Standard BLM study plots measuring 1 x 1 km have been employed for long-term desert tortoise studies. This method usually requires a survey window of 30 to 60 days, during which surveyors must cover an entire study plot. Although this is an effective method of observing most desert tortoises within the study plot, it can be both labor and cost intensive.

Smaller survey plots may sometimes yield biased population estimates. As an alternative method to the typical 1 x 1 km plots, Chambers Group (1994) conducted mark-recapture surveys for the desert tortoises on study plots that were one-quarter the size of standard BLM study plots (500 x 500 m). The results of this study were similar to those for other mark-recapture surveys, and tortoise population estimates were likely biased by a low recapture rate (Chambers 1994). This difficulty in recapture success has also been encountered with similar studies conducted by the National Park Service at Joshua Tree National Park (J. Frielich, personal communication).

For these reasons, the alternative censusing approach described for this study (Section 2.2) was used. The 1,500 x 1,500 m study plot and the configuration and placement of sample quadrats (covering 36 percent of the study plot, a total area of 0.81 sq. km) was intended to increase the surveyors' ability to encounter tortoises without increasing the area surveyed. Theoretically, by spacing the sample quadrats over a wider area during the same survey period, the potential for capture (and recapture) of desert tortoises should also increase, thus increasing recapture success and potentially developing a more reliable population estimation method.

### **4.2 DESERT TORTOISE DISTRIBUTION**

Figure 3-2 illustrates the locations of all tortoise encounters on the study plots during the 1995 study. Study plot boundaries were located using GPS field units, but could not be differentially corrected in the field. The accuracy of the study plot boundaries is within 50 m (154 ft). GPS locations were recorded for every desert tortoise encountered and were differentially corrected using base station information. This provided greater accuracy for actual tortoise observations, 2 to 5 m (6.6 to 16.4 ft). Due to the variations in accuracy of the study plot boundaries and tortoise GPS locations, Figure 3-2 shows that some desert tortoises (with the exception of the two tortoises processed on an access road northwest of plot AL-3) appear to be located outside the study plots.

Desert tortoise encounters on plot AL-2 were clustered primarily in the top or northernmost portion of the study plot (see Figure 3-2), and no tortoises were encountered in the three southernmost quadrats of plot AL-2. This phenomenon may be explained by the variation in habitat on the plot. Desert tortoises are commonly found in habitat with creosote bush, alluvial fans and/or plains, and sandy/gravel soils, which characterize the middle and top portions of plot AL-2 (Chambers 1994). The three southernmost quadrats lie on the northern edge of Coyote Lake, a dry lake bed, where the soil is more alkaline, with sand dunes and little to no creosote bush, habitat in which desert tortoises are less commonly found.

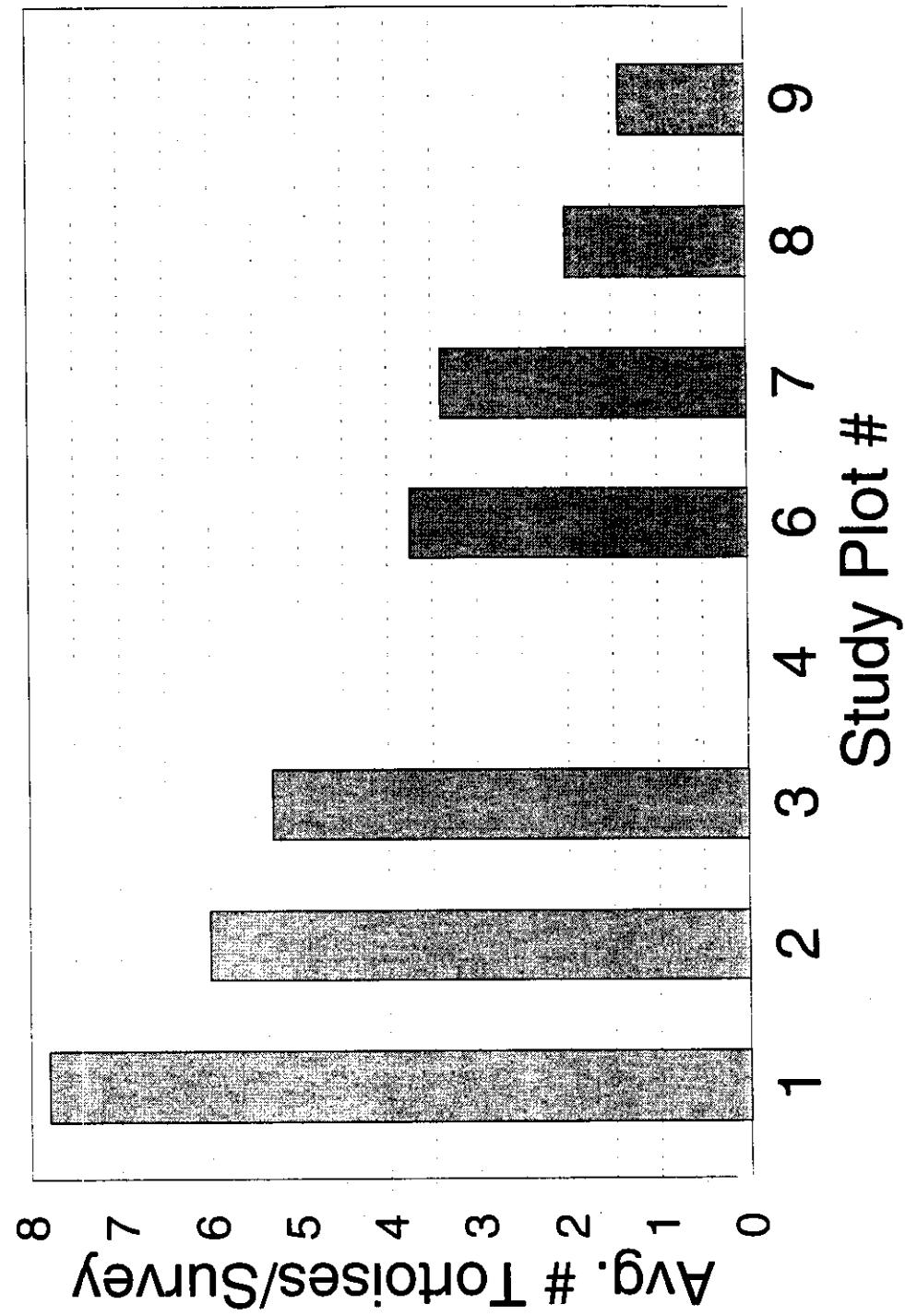
Plot AL-4 was the only plot where no live desert tortoises had been found by the third visit. The sign count was also low, with only two scat, five burrows, and two carcasses recorded after the third survey (Table 3-5). Since little tortoise sign and no tortoises were observed by the third visit, survey efforts were concentrated on the remaining seven plots. The reason for the low tortoise activity observed for this plot is unclear. The habitat was no more disturbed than for plots AL-6 and AL-3, and the habitat and vegetation were similar to the other plots on which tortoises were found. This plot should be included in surveys in the future; it may have potential to be used as a plot to relocate tortoises that are removed from areas that are being trained to the north.

Plot AL-9 was the only plot with no recaptures. It is located entirely inside the Langford Impact zone, which accounts for the highly disturbed habitat found on this plot. The high disturbance of the habitat could account for the low numbers of tortoise sign and tortoise encounters, and the absence of recaptures for this plot (Tables 3-1 and 3-4). The desert tortoises in the area may be moving through the impact zone to reach more productive and less disturbed habitat. If few tortoises are using the Langford Impact zone as a permanent part of their home range, the likelihood of recapturing a marked tortoise would be low.

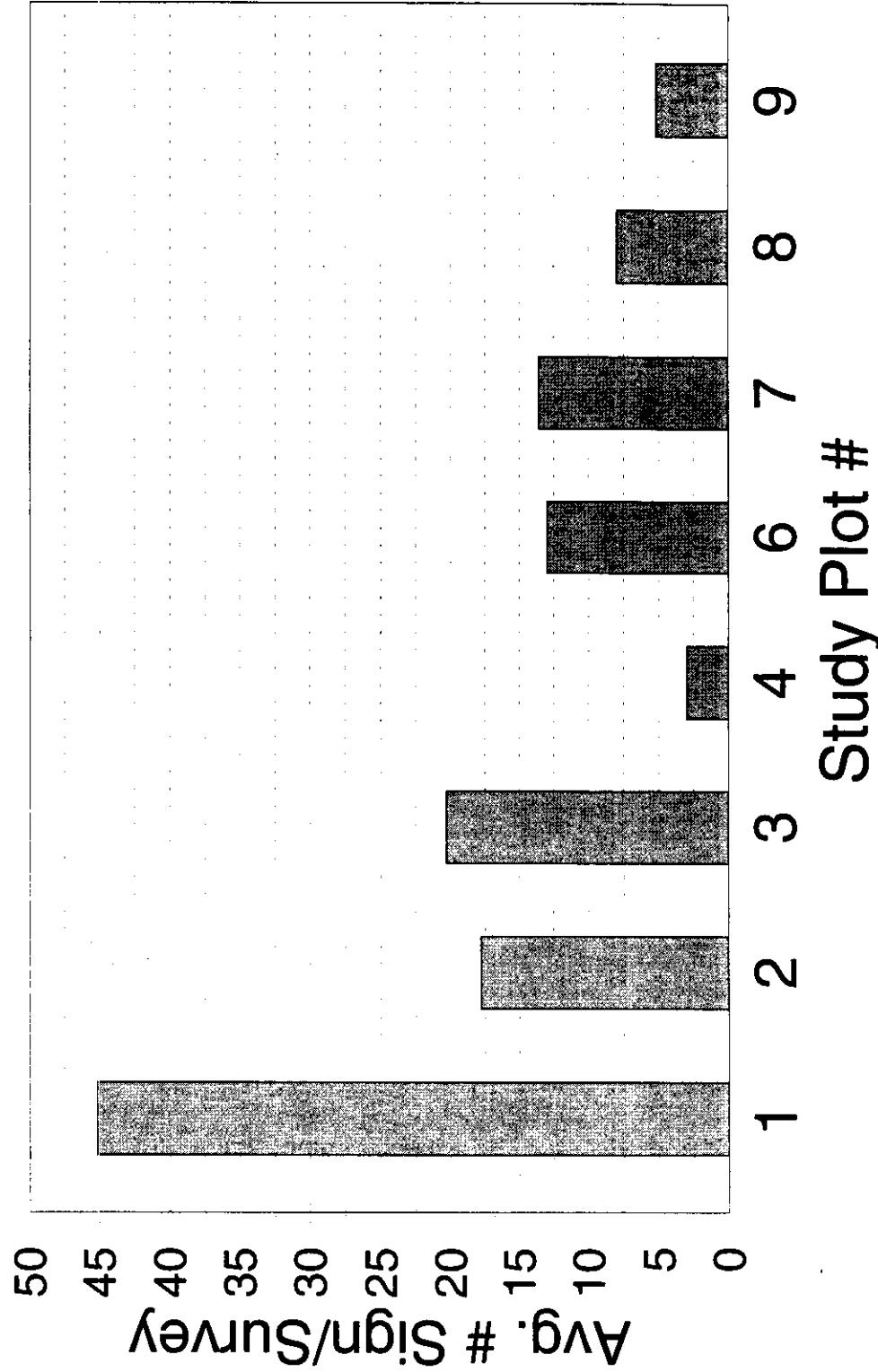
Sign was recorded to show relative use of a study plot by desert tortoises. Areas with higher densities of tortoises would also have a higher amount of sign. The data appear to corroborate this assumption. The amount of sign observed on each study plot corresponds to the number of tortoises encountered on each plot. Study plots with the highest average number of sign per survey typically had the highest average number of tortoise encounters per survey, and plots with the least amount of sign per survey had the fewest tortoise encounters per survey (Figures 4.1 and 4.2).

More male desert tortoises were encountered than female. It is not uncommon in field studies of desert tortoises to have one sex out number the other, and this phenomenon can occur in both healthy populations and populations in poor condition (Berry 1978). However, the sex ratio may not be a true reflection of the male-to-female distribution in the population. It may merely reflect a difference in the activity levels in male and female desert tortoises.

The higher ratio of adult tortoises to immatures and juveniles is also characteristic of desert tortoise surveys. This higher ratio may be due to the high mortality of young tortoises or the difficulty in observing young (Shields 1991; Luke 1990).



AVERAGE NUMBER OF DESERT TORTOISE  
ENCOUNTERS PER SURVEY FOR EACH STUDY PLOT.  
Figure 4-1



AVERAGE NUMBER OF DESERT TORTOISE SIGN  
OBSERVED PER SURVEY FOR EACH STUDY PLOT.  
Figure 4-2

#### **4.3 DESERT TORTOISE DENSITY ESTIMATES**

The objective of this study was to supply baseline information on desert tortoise density for the southern boundary region of Fort Irwin NTC. The desert tortoise density estimates for this study (Table 3-5) may not be as reliable as desired because of the extremely low recapture rate, which is typical of mark-recapture studies of desert tortoises (Freilich, personal communication; Andersen, personal communication; Chambers Group 1994).

Eight permanent study plots were established to estimate year-to-year desert tortoise density. This report presents the initial, or baseline, density estimate using the mark-recapture data. Future studies will compare tortoise densities to this baseline study to identify population trends. Because of the problems associated with calculating desert tortoise densities with few recaptures, it is recommended that raw datasets be compared as well. For example, absolute tortoise numbers (111 individual tortoises found in 37 site visits during this study) across all study plots, and for each study plot could be compared. Surveys should be conducted at the same time of year, under similar conditions, and using the same study plots and survey methods to attain similar absolute numbers for desert tortoises if the population is stable, just as would be expected using density estimates based on mark-recapture data. All data collected should be used to assess desert tortoises density trends when applicable.

## SECTION 5 - REFERENCES

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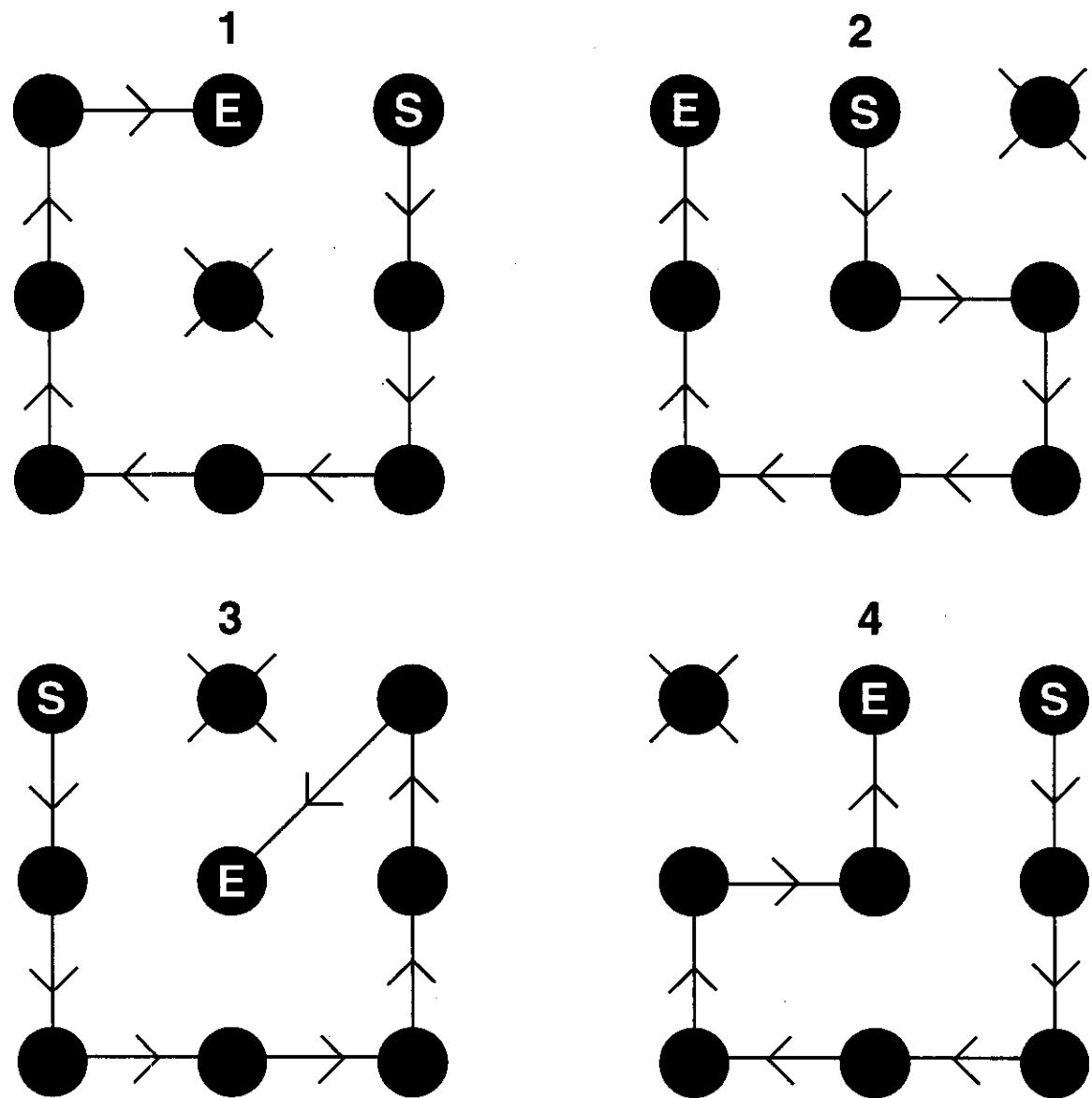
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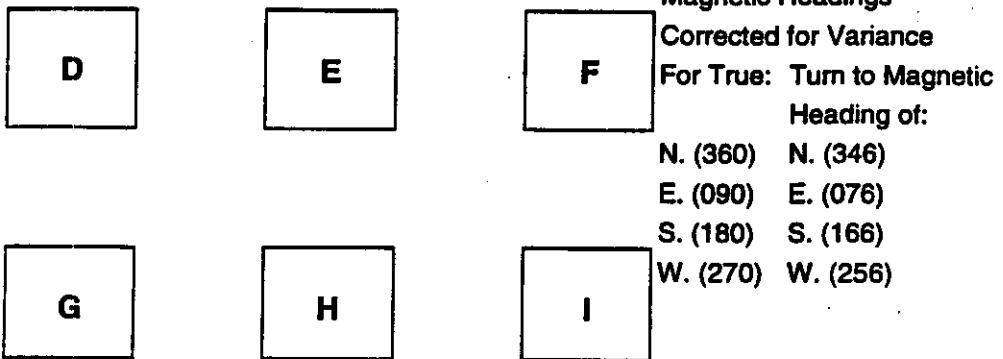
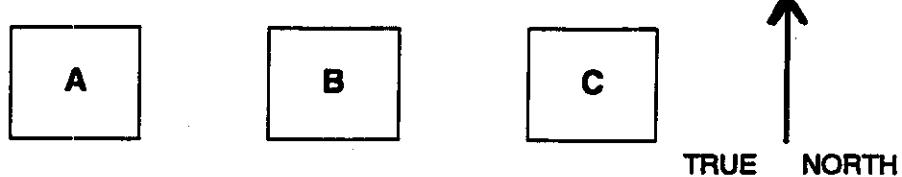
**APPENDIX A**

**SURVEY PLOT PATTERNS AND CONFIGURATION**

**LEGEND:**

- QUADRAT
- S STARTING QUADRAT
- E ENDING QUADRAT
- NEXT SURVEY QUADRAT
- ◐ NOT SURVEYED

Ft. Irwin Study Plots and Study Quadrats  
Configuration and Labeling      Study Plot AL (#)  
Quadrat (letter)



Checklist for Tortoise Processing

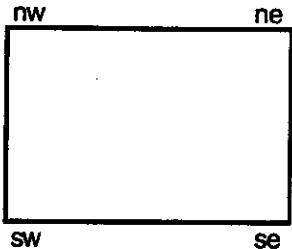
1. GPS Recording, with filename on data sheet
2. Data Sheet filled out properly and correctly
3. PIT tag and permanent number applied
4. Picture Taken

**APPENDIX B**

**SAMPLE DATA SHEETS, SPRING 1995 SURVEY**

# NTC Desert Tortoise Surveys 1995

Date(day/month/yr) \_\_\_\_\_  
 Field Team \_\_\_\_\_  
 Study area \_\_\_\_\_  
 Quadrat \_\_\_\_\_ Visit # \_\_\_\_\_  
 UTM Location \_\_\_\_\_  
 GPS file # \_\_\_\_\_  
 Photo Taken? \_\_\_\_\_



Capture Type: Initial - Recap. - Unkn.  
 Pit Tag # \_\_\_\_\_  
 Tortoise ID # \_\_\_\_\_  
 Time Observed: \_\_\_\_\_  
 Observed: On Plot -- Off Plot  
 Year first marked \_\_\_\_\_

## SHOW LOCATION OF TORTOISE IN QUADRAT

### ENVIRONMENTAL DATA

soil temp. \_\_\_\_\_  
 wind \_\_\_\_\_  
 % cloud cover \_\_\_\_\_  
**TORTOISE DATA**  
 Sex (over 180mm MCL) \_\_\_\_\_  
 MCL (mm) \_\_\_\_\_  
 weight (g) \_\_\_\_\_  
 width (at widest point) \_\_\_\_\_  
 notes: \_\_\_\_\_

### HEALTH DATA

Nostrils (circle one)  
 dry    damp    wet  
 exudate present? \_\_\_\_\_  
 bubbles from nostril? \_\_\_\_\_  
**Breathing (circle one)**  
 clear    wheezing  
 rasping    bubbling  
**Posture and Behavior**  
 Alert, responsive  
 Lethargic  
 Appendages Limp  
 Head hanging

### LOCATION

Observed in: circle one  
 open  
 shelter  
 other  
**Shelter type: circle one**  
 burrow  
 pallet  
 shrub  
 caliche cave  
 rock shelter  
**At shelter site: circle one**  
 entering  
 exiting  
 on mound  
 inside

**Behavior at time of Obs. (circle one)**  
 resting    walking  
 basking    feeding  
 plants/item eaten: \_\_\_\_\_

### Shell Wear

Lesions present  
 Sunken scutes  
 Thinning scutes  
 Peeling scutes  
 None observed

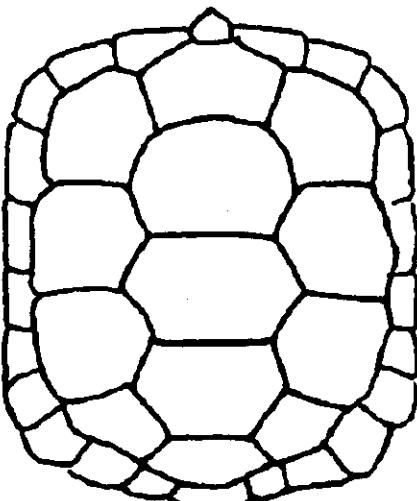
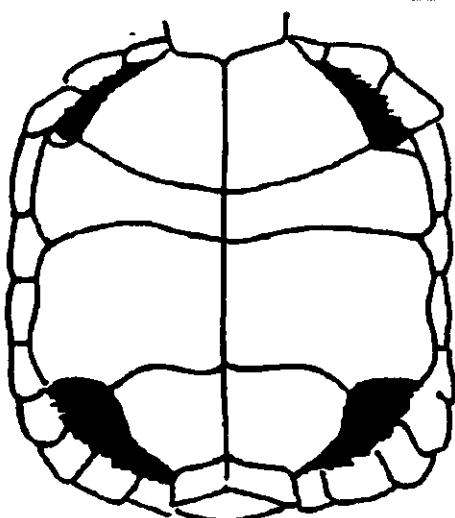
### BURROW DATA

If found in burrow:  
 orientation: \_\_\_\_\_  
 depth: \_\_\_\_\_  
 width: \_\_\_\_\_  
 height: \_\_\_\_\_

### Interacting with another tortoise:

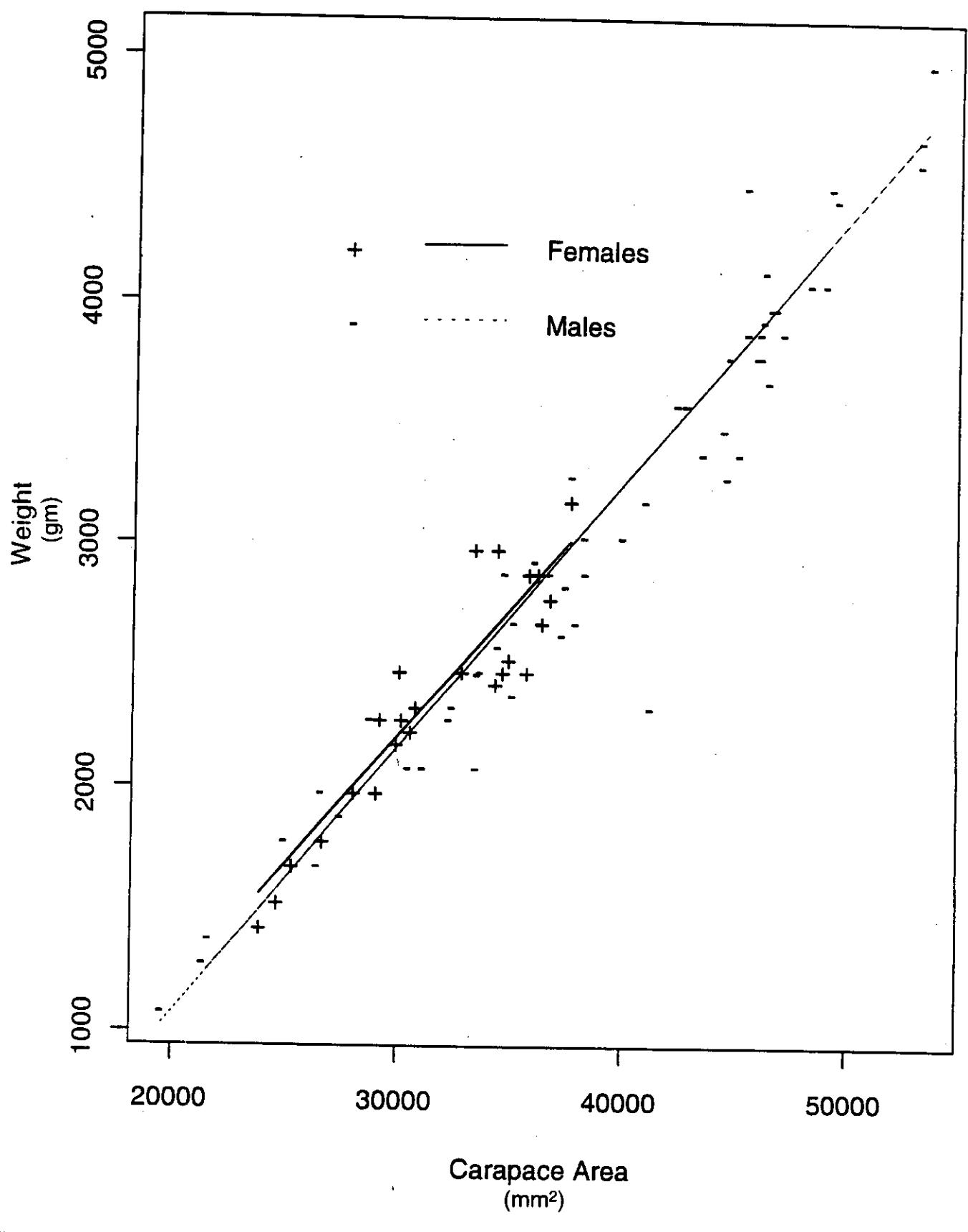
ID and sex of other tortoise:  
 Describe interaction: \_\_\_\_\_

Draw locations of incidental markings, chips, anomalies, etc. on figure provided, and describe anomalies in marking of tortoises or any other additional notes below.



## **APPENDIX C**

**SUMMARIES OF REGRESSIONS OF WEIGHT  
ON CARAPACE AREA FOR BOTH SEXES  
AND A PLOT OF THE REGRESSIONS AND  
DATA FOR MARK-RECAPTURE ESTIMATION**



**Table Summaries of regressions of tortoise weight on carapace area for the two sexes separately. For males, the residual standard error is 179.9 on 24 degrees of freedom. For females, the residual standard error is 270.1 on 64 degrees of freedom. For both regressions, the R-squared value is 0.914.**

**FEMALES**

|           | <b>Coefficient</b> | <b>Standard error</b> | <b>t-value</b> | <b>p-value</b> |
|-----------|--------------------|-----------------------|----------------|----------------|
| Intercept | -951.2996          | 301.9114              | -3.1509        | 0.0046         |
| Area      | 0.1055             | 0.0094                | 15.1610        | <0.0001        |

**MALES**

|           | <b>Coefficient</b> | <b>Standard error</b> | <b>t-value</b> | <b>p-value</b> |
|-----------|--------------------|-----------------------|----------------|----------------|
| Intercept | -1103.9512         | 165.5694              | -6.6676        | <0.0001        |
| Area      | 0.1090             | 0.0042                | 26.2355        | <0.0001        |

Data for mark-recapture estimation. Note that there were no recaptures on plots AL4 and AL9.

| Sample          | Number captured | Number marked in sample | Number marked in population |
|-----------------|-----------------|-------------------------|-----------------------------|
| <b>Plot AL1</b> |                 |                         |                             |
| 1               | 12              | 0                       | 0                           |
| 2               | 4               | 0                       | 12                          |
| 3               | 6               | 0                       | 16                          |
| 4               | 9               | 2                       | 22                          |
| 5               | 6               | 3                       | 29                          |
| <b>Plot AL2</b> |                 |                         |                             |
| 1               | 7               | 0                       | 0                           |
| 2               | 4               | 2                       | 7                           |
| 3               | 5               | 1                       | 9                           |
| 4               | 7               | 3                       | 13                          |
| <b>Plot AL3</b> |                 |                         |                             |
| 1               | 2               | 0                       | 0                           |
| 2               | 4               | 0                       | 2                           |
| 3               | 5               | 0                       | 6                           |
| 4               | 6               | 1                       | 11                          |
| 5               | 3               | 2                       | 16                          |
| 6               | 8               | 4                       | 17                          |
| <b>Plot AL6</b> |                 |                         |                             |
| 1               | 3               | 0                       | 0                           |
| 2               | 3               | 0                       | 3                           |
| 3               | 2               | 0                       | 6                           |
| 4               | 2               | 1                       | 9                           |
| 5               | 5               | 2                       | 9                           |
| <b>Plot AL7</b> |                 |                         |                             |
| 1               | 2               | 0                       | 0                           |
| 2               | 2               | 0                       | 2                           |
| 3               | 8               | 2                       | 4                           |
| 4               | 4               | 0                       | 10                          |
| 5               | 1               | 0                       | 11                          |
| <b>Plot AL8</b> |                 |                         |                             |
| 1               | 4               | 0                       | 0                           |
| 2               | 3               | 1                       | 4                           |
| 3               | 3               | 1                       | 7                           |